FIRE ECOLOGY OF THE LASSEN NATIONAL FOREST

SUSAN HUSARI

ALMANOR RANGER DISTRICT

May, 1981

United States
Department of
Agriculture

National Agricultural Library

TABLE OF CONTENTS

INTRODUCTION

The following is a survey of the fire ecology of cover types found on the Lassen National Forest. Most of the cover types correspond directly to the Cal. Veg. series or formations listed for the North Interior Ecological Province. There are two exceptions. First, if there are no defined differences in fire ecology between two or more Cal. Veg. series, they are grouped together. Second, when a Cal. Veg. series includes significantly different fire ecology types, finer divisions are made.

Tables useful in correlating regional timber and range types with Cal. Veg. can be found in the January, 1981, Cal. Veg. update (Regional Ecology Group, 1981).

The cover type describe vegetation existing on the Forest. When fire management policies or natural fire occurrence influence future succession and community structure, the potential vegetation is described, also by type.

The major types are organized into 6 sections. The first is a general description of the type. The second gives fire adaptations of species. Here, the effects of fire on each species within the cover type are explored. A species' fire related reproductive strategies and the direct effects of fire on individuals of all ages are described. The third division is fuel loadings. Both the character and amounts of dead fuel loadings and the influence of live fuels are included. Fourth, fire behavior is described for each cover type. Fifth, successional patterns are given. Finally, a section giving effects of fire on other resources is included, if necessary.

For clarity, ecological terms are defined here. Kershew (1973) defines succession as "directional vegetative change induced by environmental changes or by intrinsic properties of plants." Climax is defined "as a self-perpetuating association of plants having a maximum of stability." A fire maintained type is not a climax because without fire, community structure and vegetative composition change. When fire maintains a stable community, be it brushfield, meadow, or conifer type, it is called a disclimax.

MIXED CONIFER-FIR HABITAT TYPE

Cal. Veg. Series: Mixed Conifer-Fir Series

The mixed conifer-fir type is composed of Jeffrey pine, ponderosa pine, sugar pine, white fir, incense cedar and western white pine. There is an understory of mountain whitethorn, greenleaf manzanita, pinemat manzanita, squaw carpet and chinquapin.

Fire Adaptations

Adaptive features of trees in this type are best viewed as a gradient of fire and shade tolerances. Jeffrey and ponderosa pines are the most fire resistant members of the pine-fir community. Both species reproduce best in the sunny openings and mineral seedbed produced by fire. Lodgepole pine, sugar pine and western white pine are of moderate fire resistance, but are more shade tolerant than the yellow pines. Incense cedar and white fir are shade tolerant. They are very susceptible to fire damage when young because of thin bark. Incense cedar increases in fire tolerance with age because of self-pruning, a high canopy and thick bark.

Fuel Loadings

Fuel models are best represented by NFDRS model G & NFFL model 10 (Deeming et al, 1977). NFDRS J and K and NFFL 11 and 12 represent areas with slash. Fuel loadings can reach 50 tons per acre on mature mixed conifer sites. In yellow pine-fir areas with a dense understory the closest approximation of the fuel situation is the photo series 4-WF-2 and 2-WF3 models (Blonski and Schramel, 1981). These models show suppression mortality at 20 tons per acre with heavy loading in the 3 to 9 inch and smaller size classes.

Fire Behavior

The mixed coniferous forest is highly flammable, especially after many years of fire suppression. Many mixed conifer-fir areas have an overstory of pine, incense cedar and white fir with a dense understory of white fir. Live fuel ladders, a well aerated and continuous fuel distribution and the fuel size class

pattern indicate rapid rates of spread under dry, windy conditions or on steep slopes. Torching is possible when flame lengths reach from the understory into the canopy. Die off of young fir is likely after scorching by a fire of moderate intensity. The dead trees contribute to an extreme fuel situation.

A whole range of fuel loadings and fire potentials exist in this cover type, depending on location and fire history. Fire behavior is variable and should be of moderate intensity except where suppression mortality and heavy fir invasion creates fuel ladders and heavy loadings in the small size classes. In these cases crowning behavior is possible.

Succession

The proportion of each tree species in the population is governed by elevation, precipitation and fire frequency. The mixed conifer-fir cover type occupies the belt between the yellow pine and fir types where the natural period between fires is long enough to allow the establishment of fire intolerant species. Natural fire period probably ranges from 20 to 50 years. More frequent fire shifts the balance towards the fire adapted pines and less frequent fire favors a higher percent of white fir and incense cedar in the stand. Fire intolerant species survive as a larger portion of the population only if young trees remain undisturbed until old enough to withstand low intensity fire (Van Wagtendonk, 1972). The fire maintained mixed conifer habitat is distinguished by a mixture of mature fire tolerant and intolerant trees in the overstory. Some areas on the Forest have stand structure characterized by mature lodgepole or yellow pines and a dense understory of developing white fir. These areas are examples of lodgepole or Jeffrey pine cover types where fire has been excluded.

The progress of succession in pine-fir cover type depends on the frequency of fire. Without fire these areas will become fir stands in time. Periodic fire maintains a mix of fire tolerant and intolerant conifers. Intense, stand-destroying fire converts the habitat to a montane chaparral type.

JEFFREY PINE COVER TYPE

Cal. Veg. Series: Ponderosa Pine and Jeffrey Pine

The Jeffrey pine cover type includes both ponderosa and Jeffrey pine. The literature does not describe enough differences in fire ecology to justify separate treatment of the two species.

The cover type is divided into two subtypes based on differences in succession and climate. The first is a xeric type that supports a ponderosa or Jeffrey pine climax. The second is a mesic site with sufficient rainfall to favor other tree species when fire is excluded. Here yellow pine stands are maintained by periodic fire.

XERIC PINE

This type occurs on the eastern slope. It is distinguished from the mesic type by the presence of Great Basin shrub species and the lack of white fir in the understory.

It is found between 3000 and 7000 feet in large tracts, often on flat ground. Jeffrey and ponderosa pine are the dominant tree species. They grow in association with incense cedar, black oak, sugar pine and western juniper.

Fire Adaptations of Species

Ponderosa and Jeffrey Pine

Ponderosa and Jeffrey pine have the full array of fire adaptations. The mineral seedbed exposed by burning is favorable to seedling establishment. The seedlings are shade intolerant and are adapted to withstand arid conditions. Early development of insulative bark, meristems shielded by needles and bud scales, high moisture content in living needles and rapid extension of taproots are characteristics which reduce the mortality of young trees from fire.

Fire rarely reaches the crowns of mature trees. The bark is thick and corky, insulating the cambium from heat damage. The bark and the branches support little flammable lichen growth. Self pruning of lower branches and high moisture content in needles discourage fire spread into the open, high crowns.

Dwarf mistletoe is a serious problem in the xeric pine type. Periodic fire controlled the spread of the disease by burning more intensely in the heavy fuel accumulations it caused. Diseased pines made flammable by fallen witches brooms and dead branches are eliminated by fire (Alexander and Hawksworth, 1975). Burning of stumps eliminates infection sites for <u>Fomes annosus</u>. <u>Elytroderma deformans</u>, a needle disease common on the Lassen, may be inhibited by fire (Van Wagtendonk, 1972).

Western Juniper

Young junipers are easily killed or damaged by fire due to thin bark and flammable foilage. Older trees survive low to moderate intensity fire because of their thick bark. However, they burn very intensely if fire climbs the low, spreading branches and ignites the pitchy foliage.

Incense cedar

Mature incense cedar resist fire damage because of thick bark and high, open canopy. Young trees are easily killed because the bark is very thin.

Sugar Pine

Sugar pine are intermediate in fire tolerance.

Black Oak

Black oak is increasing as a component of the yellow pine forest, especially on the Hat Creek District. It benefits from fire exclusion because trees of all ages are damaged by fire. It can resprout, however, after intense, stand destroying fire.

Antelope Bitterbrush

Bitterbrush is widespread in the understory of xeric pine stands. It is killed by intense or late season fire. It is less sensitive when the soil is damp and may resprout after spring burns. It is probable that bitterbrush was less common when fire was frequent, found only in rocky areas where fire did not readily spread (Johnson and Smathers, 1976).

Rabbitbrush

Rabbitbrush is affected favorably by fire, usually increasing as a vegetative component when fire is frequent. Green rabbitbrush resprouts from the root crown. Grey or rubber rabbitbrush is an epicormic sprouter, meaning that it can sprout only from the stems. Both are aggressive colonizers of disturbed areas. Their seed is carried long distances by the wind.

Mountain Big Sagebrush

Mountain big sagebrush is killed by fire. It is eliminated from pine stands where fire is a frequent visitor. If there is sufficient fine fuel to carry fire between plants, it burns intensely and does not resprout. It will reseed heavily if burned in the fall after seed has set (Wright, Neuenschwander and Britton, 1979).

Curlleaf Mountain Mahogany

Curlleaf mountain mahogany is easily damaged by fire and has no fire related reproductive strategies. Its chief protection from fire is its habitat; it grows on rocky outcrops where fire does not spread.

Grasses

Bluebunch wheatgrass and squirreltail recover quickly after burning, unless burned under drought conditions. Idaho fescue and needlegrasses are damaged because their dense, fine foliage smoulders at high temperatures after a fire has passed (Wright, Neuenschwander and Britton, 1979). Mortality is lessened when fires burn while the soil is damp.

Fuel Loadings

Jeffrey pine fuel loadings are described by NFDRS model U and NFFL model 9. Periodic fire keeps fuel loadings light, ranging from 2 to 14 tons per acre (Blonski and Schramel, 1981). In open, old-growth stands loadings tend to be lightest, but are highly flammable. Dead fuels consist of dry, loosely-packed needles, grass, scaley bark and cones with scattered dead branches and occasional down logs.

With fire exclusion the fuels are modified. Pre-commercial thinning and logging leave unnaturally high fuel loadings. Slash from precommercial thinning can reach 30 tons per acres with heavy loadings in the small size classes (Maxwell and Ward, 1976). The well aerated fuel structure and flashy fuels persist because weathering, compaction and decay are slow under arid conditions. In these areas NFDRS models J or K and NFFL models 11 and 12 best describe fuel conditions.

Fire exclusion has allowed the growth of a fire intolerant brush understory, chiefly mountain big sage and antelope bitterbrush.

Fire Behavior

The rate of fire spread can reach 15 chains per hour in the Jeffrey pine habitat. Usual spread rates are less than 3 chains per hour. Fires in the natural pine vegetation type are ground fires with flareups in brush patches, dense regeneration and heavy fuel accumulations. The pine needle litter is very flammable. Sufficient needles fall to carry fire yearly (Van Wagtendonk, 1972). Van Wagtendonk contrasts the frequent release of small amounts of energy by burning of the litter layer to a massive release of heat energy following a long period of fire exclusion and fuel buildup. Still, crown fire is unlikely in most stands. In open stands high winds or steep slopes do little to increase the chances of crown involvement because of the horizontal slant to the flames and the height of the crown. Certainly, these conditions may increase the rate of spread of the fire. When flame lengths exceed 3 feet, occasional torching will occur in dense pockets of young trees where suppression mortality produces fuel ladders and loadings of 8-10 tons per acre.

The abundance of mature pines with multiple fire scars indicates past fires were of moderate intensity. Fires of low intensity also occurred but were not always recorded in tree ring or fire scar data. Typical natural fire behavior cleaned the stand and promoted uneven-aged structure. Fires burned quickly through the yellow pine type, going out rapidly when weather conditions were unfavorable.

Fire exclusion and harvesting and thinning practices mean more extreme fire behavior and greater resistance to control in the xeric yellow pine habitat. Rate of spread and resistance to control increase in thinning slash. Rates of spread are rapid when the dry needles remain on the slash. Greater heat intensities and fuel ladders increase the chances of killing trees or of crown involvement.

Live fuel moisture in the shrub understory influences fire behavior. After the grass cover cures in July it will readily carry fire between shrubs. The moisture content of the dried grass corresponds to that of one hour time lag fuels. Juniper and curlleaf mountain mahogany fluctuate little in live fuel moisture over the fire season. Big sage and bitterbrush fluctuate 100% in live fuel moisture from June to September. Researchers at Lava Beds National Monument found that these two shrubs will burn when live fuel moisture reaches 130-170% and must be over 100% to keep rate of spread and flame lengths manageable (Olson, 1978).

Succession

Estimates of pre-suppression fire frequency in the xeric pine type range from 10-15 years. A six year periodicity is proposed for the ponderosa pine stands in Lava Beds National Monument (Johnson and Smathers, 1976). Periodic fire affects stand structure, productivity and vegetative composition.

Fire creates small openings favorable to the establishment of pine regeneration. It temporarily reduces competition from grass and brush. Heavier fuel accumulations, especially needle mats under mature trees, burn

most intensely, selectively thinning seedlings or young trees established after previous fires. Overall, frequent fire thins and opens the stand, producing a mosaic of different age groups (Wright, 1978).

Old trees often have heavy dead limbs near the ground, indicating that presuppression stand structure was open with sunlight reaching down to the ground (Hall, 1977).

Without the thinning effects of fire, overstocking of Jeffrey and ponderosa pine can occur. Competition for light, and on xeric sites, for water, slows growth and can cause stagnation. Hall, (1977) suggests that accumulations of ponderosa pine needles contain chemicals that inhibit the growth of pine seedlings. If this is true, periodic reduction of the litter layer by fire would stimulate growth.

Periodic fire keeps dead fuel loadings light and fire intensities low. Heavier fuel levels develop during long fire free intervals. As fuel levels and stocking increase so do fire intensities and potential. Wildfire can damage or destroy trees growing under these conditions.

Periodic fire influences the composition of the understory. Bitterbrush, big sage and curlleaf mountain mahogany would become less prevalent should periodic fire be reintroduced. Overall percent of grass cover would go up and shrub cover would go down. Historical records from Lava Beds National Monument indicate a gradual change from grass to shrub cover in the last 100 years (Johnson and Smathers, 1976).

MESIC PINE

The mesic pine cover type is found on the western slope below the mixed conifer zone. Ponderosa pine is the dominant species, with white fir, incense cedar, black oak and sugar pine as associates. Mountain misery is an understory component in the portion of the Shasta-Trinity administered by the Lassen near Goose Valley.

Fire Adaptations of Species

Ponderosa and Jeffrey Pine

The fire adaptations outlined for xeric site pine are essential to the maintenance of mesic yellow pine stands. These qualities give the yellow pines a competitive advantage over shade tolerant competitors in the presence of fire.

White Fir

White fir under 6" dbh are poorly adapted to withstand wildfire (Olson, 1981). Bark is very thin, is photosynthetic and has resin blisters. The cambium of seedlings can be heat damaged by sunlight. Young trees grow in dense stands with flammable foliage reaching to the ground. The root systems are shallow. Mature trees develop a thicker bark that is resistant to low intensity fire. However, they are susceptible to rot if damaged.

Others

Incense cedar and sugar pine are rated intermediate in fire tolerance. Young trees have thin bark and are often killed by fire but older trees withstand fire well.

Fuel Loadings

Fuel loadings are best described by NFRDS models I, J or K and NFFL models 11 and 12 in thinning slash. Natural fuels are described by NFDRS model U and NFFL model 9.

Fuel loadings are slightly heavier than those found in xeric pine stands but remain lighter than in most other cover types. They range from about 5 to 30 tons per acre (Maxwell and Ward, 1980). If fuels reach 30 to 40 tons per acre they are usually concentrated above the 9-inch size class and influence resistance to control rather than rate of spread.

Fire Behavior

Fire behavior is similar to that described for xeric pine stands. Increasing invasion of pine stands by young white fir and incense cedar means greater intensities and resistance to control. Thinning slash left in the stand has similar effects. Brush cover is chiefly greenleaf manzanita, chinquapin and mountain whitethorn. Live fuel moistures drop in late August and increase intensity if ignitions occur before the first rains.

Fuels ladders from white fir invasion are the greatest hazard in this cover type.

Succession

Fire is essential to perpetuation of mesic pine stands. Increment cores show that, prior to suppression, fires burned at average intervals of 11 years in Lassen Park's pine stands (Swanson, 1980). Frequent fire prevented the establishment of the fir climax and maintained the pine disclimax.

Periodic fire prepares the open seedbed necessary to pine regeneration. Periodic surface fire reduces competition by killing incense cedar and fir seedlings while leaving a high percentage of young pine. It maintains a ground cover of grass. Under a natural fire regime, the habitat type remains open with evenly-spaced trees. Frequent, low intensity fires select for and maintain an uneven aged structure. Windfall, disease and fire create small openings favorable to establishment of pine regeneration (Wright, 1978).

With fire exclusion, encroaching white fir creates a dense understory. Without the thinning effects of fire, pine regeneration is dense and overstocking and suppression mortality result (Wright, 1977). Fuel ladders develop that can carry fire into the crowns of pine and its associates. When crown scorching occurs pines are stressed and become vulnerable to insect and disease infestation. Insect kill and mistletoe damage contribute substantially to fuel buildup. Eventually, fuel accumulations and undergrowth reach levels that indicate severe fire behavior that

converts the area to the chapparal cover type. Without fire the fir understory matures, the veteran pines die and the pine habitat becomes a white fir or pine-fir stand.

MOUNTAIN HEMLOCK COVER TYPE

Cal. Veg. Series: Mountain Hemlock

The mountain hemlock cover type occurs at 7500-9000 feet, nearly exclusively on north or east slopes and at the heads of drainages. It grows in pure stands or in association with red fir or whitebark pine.

Fire Adaptations of Species

Mountain hemlock is poorly adapted to withstand fire. It has a shallow root system and relies on a persistent snow pack to provide moisture through the short growing season (Sudworth, 1967). The canopy droops nearly to the ground even in maturity and provides a fuel ladder. The foliage is dense and very flammable (Davis, Clayton and Fischer, 1980). Trees clump in tight groups. Mortality from scorching is high (Mastrogiuseppe, 1980). Heart rot is common and, when present, causes affected trees to catch fire easily and burn intensely.

Fuel Loadings

Fuel loadings are characterized by NFDRS model H and NFFL model 8. Fuel load data from the mountain hemlock type in the Caribou Wilderness showed 14 tons per acre. Fuel continuity and size class information is found in the Lassen natural fuels photo series (Blonski and Schramel, 1981).

Relationship to Fire

Fire behavior in mixed mountain hemlock stands has been observed in Crater Lake National Park and Yosemite National Park (Botti, 1980; Sholley, 1980). Fire can burn intensely if fuels dry out. Starts are rare because of moist

conditions, even though lightning strikes occur. Fire periodicity is estimated at 200-300 years. Dense stands occur in the Caribou but cover small acreage. Most mountain hemlock habitat has less than 50% cover and is not likely to sustain fire under all but extreme conditions.

Succession

The distribution of mountain hemlock is heavily influenced by two factors. First, young trees can outcompete red fir in areas where snow accumulates in drifts and melts late in the year. Second, red fir has a competitive advantage on drier sites because of deeper root system and because it is better able to withstand fire.

LODGEPOLE COVER TYPE

Cal. Veg. Lodgepole Pine Series.

This cover type usually occurs in tracts of 200 or more acres on flat upland areas and rolling terrain. Often, the uplands drain into pothole lakes and sinks with little surface water flow. The major conifer species is lodgepole pine, with a sprinkling of western white pine, ponderosa pine and Jeffrey pine. On much of the Forest there is a developing understory of white and red fir.

Fire Adaptations of Species

Periodic fire favors the maintenance of the lodgepole pine cover type. This relationship with fire is due more to the adaptability of the lodgepole pine reproductive cycle than to the fire resistance of individual trees. Lodgepole is rated intermediate in fire tolerance (Davis, Clayton and Fischer, 1980). It has thin bark; young trees do not self prune; they grow in dense thickets and older trees are susceptible to butt rot. However, lodgepole is better able to withstand fire than its competitors.

Lodgepole seedlings are shade intolerant. Seeds germinate best in the openings and sterilized, mineral seedbed produced by high intensity fire or disturbance. Locally, lodgepole cones are not serotinous, but seeds are

produced in abundance every year. Lodgepole sets seed at an early age. The combination of heavy, early seed production and the ability to reseed any openings that occur give lodgepole pine a competitive advantage over its associates in the presence of fire whether of low, medium or high intensity.

Fuel Loadings

Lodgepole pine stands on the Lassen National Forest fit either NFDRS models G or H depending on the amount of dead and down fuels. They most closely correspond to NFFL Models 8 or 10.

Present fuel loadings in the lodgepole habitat vary according to location. Lodgepole stands in the Caribou Wilderness are approximately 100 years old with fuel accumulations of 5 to 10 tons per acre. Higher loadings occur in the forest in older or more dense stands. Areas of 25 tons/acres are found in Clover Valley on the Almanor District. Loadings can reach 30 tons per acre in blowdown areas (Blonski and Schramel, 1981). They exceed 60 tons per acre in isolated stands on the Eagle Lake District (Olson, 1981). Dead fuels are mostly of the larger size classes. Litter layers are light and brush cover, mostly pinemat manzanita, is patchy.

Fire Behavior

Fire behavior is related to the amount and size distribution of dead and down fuels. Fuel levels in lodgepole stands are determined by the age and decadence of the stand, the frequency and intensity of fire and by stand structure.

Generally, lodgepole stands less than two hundred years old burn with low to moderate intensity. Duff and ground fuels are light. Indicated rates of spread in these fuels are under 5 chains per hour even with high winds and low fuel moisture. The main exceptions to this rule are dog hair thickets where lodgepole has seeded heavily following fire (Davis, Clayton and Fischer, 1980). Size Class 2 lodgepole can exceed 2000 trees per acre

(Blonski and Schramel, 1981). Suppression, blowdown and snow damage can cause heavy, well aerated fuel accumulations with loadings concentrated in the 1 to 3 and 3 to 9 inch size classes and 90% residue coverage. When fuel moisture drops, rapid rates of spread and high flame lengths are postulated (Ward and Sandberg, 1980).

After a stand reaches 200 years of age disease and decadence begin to add more rapidly to fuel loadings. Most of the fuels produced, however, are in the 3 to 9-inch and larger size classes. These dry slowly, especially since many dense lodgepole stands grow in very wet areas. These areas may never dry sufficiently to support fire unless yearly precipitation drops below normal. Stands on drier or less productive sites tend to be more open with lighter fuel loadings. Natural fire periodicity in such areas is more frequent and of low to moderate intensity.

Succession

Lodgepole has long been considered a seral stage, to be replaced by fir in the absence of fire. Its prolific ability to revegetate openings allows it to follow fire on soils suitable to fir, but it can also grow on sites where fir cannot. Frost pockets and poorly-drained soils may be the edaphic factors that define a lodgepole climax in our area (Pfister and Daubenmire, 1973). Regardless of whether lodgepole is a seral stage or a climax species, its relationship to fire is the same.

The chief effect of exclusion of fire from the lodgepole habitat type has been the growth of an understory of fir. Without periodic fire fir will dominate on suitable sites. Natural fire occurrence would select for lodgepole.

After a fire, lodgepole revegetates openings. If a thick stand develops, suppression mortality produces a crisscross of fuels. Mountain pine beetle epidemics, dwarf mistletoe, needle miner epidemics and other disease cause more fuels to accumulate. The development of an understory of fir creates fuel ladders that increase fire potential. Mortality from moderate fire adds to the overall fuel load. When fuel loadings reach critical levels

fire can consume the stand (Brown, 1973). This interrupts the succession and returns the stand to lodgepole. Large even-aged stands, such as occur in the Caribou Wilderness, may be a result of this successional pattern (Johnson, 1980).

Small or moderate intensity fires favor perpetuation of the lodgepole cover type. Mature lodgepole pines in the Caribou Wilderness often have single and occasionally have multiple fire scars (Swanson, 1980). This suggests that fires often are of a low or moderate intensity that does not kill the overstory. Moderate fire serves to increase the percentage of lodgepole in a mixed conifer or uneven-aged lodgepole stand because lodgepole is better able to withstand fire than its competitors. It has an added advantage because it sets seed at an early age, reseeding any openings that may occur. Uneven-aged stands may indicate a history of low intensity burns or small fires. Very low intensity fire may not open the stand sufficiently to allow establishment of a new age class, hence the occurrence of fire scarred overstory trees and no young lodgepole in some areas.

MIXED CONIFER-PINE

Cal. Veg. Series: Mixed Conifer-Pine

Mixed conifer-pine is a transistional type that blends the oak and chaparral of the front country with the conifer zone. The species mix is determined by fire frequency and elevation. Tree species are Douglas fir, incense cedar, white fir, ponderosa pine, sugar pine and black oak. The brush understory includes deerbrush, dogwood, mountain whitethorn, greenleaf manzanita, squaw carpet, currant, chinquapin and tobacco brush.

Fire Adaptations of Species

Ponderosa Pine

Frequent fire gives ponderosa pine a competitive advantage over all other trees found in the mixed conifer-pine type. Ponderosa pine regenerates on the mineral soil and in the sunny openings produced by fire. Young trees develop fire resistant qualities rapidly. Mature trees resist fire damage.

Douglas Fir

Douglas fir regenerates well on a mineral seedbed. Elimination of duff by fire allows shallow taproots to penetrate the soil (Davis, Clayton and Fischer, 1980).

Young trees are susceptible to fire damage. They grow in dense, flammable thickets. Thin bark and resin blisters allow cambium damage.

Mature trees develop thick, fire resistant bark. Fire can kill the cambium along gum cracks (Davis, Clayton and Fischer, 1980).

Incense Cedar and Sugar Pine

Both incense cedar and sugar pine are rated intermediate in tolerance to fire. Young trees are often killed by fire but mature specimens withstand low to moderate intensity fire without damage.

White Fir

White fir is the least fire tolerant of the trees in the mixed conifer-pine type. Germination will occur in shade on duff. Saplings and young trees are easily killed by fire.

Black Oak

Black oak has high fire mortality until 60 years of age (McDonald, 1980). The bark does not provide adequate insulation to prevent scorching of the cambium. Trees resprout vigorously after burning.

Deerbrush

Deerbrush can germinate without seed scarification but much larger numbers of seedlings are found after a burn. The deerbrush understory becomes decadent and dies out if fire is excluded for long periods. Seed remains viable in the soil for many years.

Fuel Loadings

Fuel loadings are best described by NFDRS slash model J or K and NFFL models 11 or 12. Areas without slash fit fuel model G and NFFL model 10.

Down fuel loadings can reach 60 tons per acre and depend on the amount of slash from past activities (Maxwell and Ward, 1979).

Fire Behavior

The mixed conifer-pine type is very flammable. Fuel loadings, both as a result of timber harvesting and natural accumulation, are high. Stand structure is even-aged and composed of younger, more flammable age classes. Species composition has shifted to a higher percentage of fire sensitive, flammable trees. A dense understory of Douglas fir, white fir and incense cedar burns readily and forms fuel ladders into larger trees. Decadent deerbrush and heavy down fuels contribute to fire potential. Rate of spread and resistance to control are increased by steep topography. Fire can easily spread from the flammable, fire dependent front country types to the adjacent mixed conifer-pine type.

Fire behavior indicated by these conditions is extreme. Summertime weather is hot and dry. Fuels dry more quickly than in higher elevation types. The mixed conifer-pine type is more susceptible, in its present condition, to fast moving crown fire than any other conifer type.

Succession

Historically, succession and species composition in the mixed conifer-pine type was controlled by frequent, low intensity fire. Mixed conifer stands were almost immune to crown fire (Kilgore, 1973). Fires occurring every 15-20 years reduced fuel loading and selected for fire resistant species. Germination of trees requiring sunlight and a mineral seedbed was favored over shade tolerant speices. The understory was open because frequent fire reduced dense brush growth.

The present mixed conifer-pine type bears little resemblance to historic mixed conifer stands. It has been modified by timber harvest and fire exclusion. Species composition, stand structure, understory composition and fuel loadings are altered. Stand destroying fires could now consume many areas. Low to moderate fir occurs only under limited, controlled prescription.

Stand structure is young and even aged with a developing understory of shade tolerant trees. The species mixture tends towards Douglas fir, white fir, and incense cedar. Pines occur as veterans or in plantations. Black oak has increased in frequency as conifers were logged.

Changes in the mixed conifer-pine type will continue to be dictated by timber harvesting and silvicultural practices. Succession, however, can be drastically altered where stand destroying fires burn. Fire converts the type to fields of non-sprouting manzanitas, deerbrush and black oak. Past practice has been to plant pine with varied success. It is possible that the conifer zone has moved up in elevation as fires in the last century destroyed timber near the transition between chaparral and mixed conifers. It is difficult to provide the conditions necessary to the growth of young trees in this transitional area.

WHITEBARK PINE COVER TYPE

Cal. Veg. Series: Whitebark Pine

Whitebark pine is the highest elevation conifer cover type.

Whitebark pine grows in thick clumps or hedges scattered among rocks. Lightning strikes may ignite individual clumps. These burn intensely because of the dense, brushy habit and pitchy bark. A fire of appreciable size is ruled out because fuels are discontinuous. Vegetation cover rarely exceeds 50% in this vegetation type.

RED FIR-WHITE FIR COVER TYPE

Cal. Veg. Series: White Fir, Red Fir, Red Fir-White Fir

True fir distribution can be divided into three elevational belts. White fir is found from 3500 to 6000 feet, a mixed red and white fir zone from 6000 to 7000 feet, and pure red fir stands above 7000 feet. The exact ranges depend on local factors. Western white pine, sugar pine, lodgepole pine and incense cedar are associates.

The understory can be almost nonexistent in old-growth fir stands. Light is insufficient to support fir regeneration except where the canopy is opened. In more open stands with frequent rock outcrops or talus slopes, such as typify much of the upper elevations of the Forest, chinquapin, pinemat manzanita and young fir form an understory.

Fire Adaptations of Species

Red and White Fir

Fir seedlings are shade tolerant and highly susceptible to fire. Thin, photosynthetic bark and resin blisters make them vulnerable. The habit of seeding in thickets encourages destruction by fir. The branches are dense and the trunks do not clean well.

Mature trees develop thick bark making them moderately resistant to low and medium intensity fire. However, their resistance is limited because of shallow root systems and heavy lichen growth.

Fuel Loadings

Fuel loadings are described by NFRDS models G or H depending on the amount of natural fuels. These correspond to NFFL models 8 and 10. Dead fuels build up in the fir habitat type when fire is infrequent. Mature fir forests have extensive dead fall and broken tops. Loadings generally range from 5 tons per acre in the Caribou Wilderness to 45 tons per acre in old-growth stands with extensive dead fall. In areas of higher loadings, the majority of fuels are of the largest size classes.

Fuel loadings to 100 tons per acre are possible on partial cuts where logs have not been yarded (Maxwell and Ward, 1979). Again, however, loadings are concentrated in the large size classes. Slash models can be used to describe fuels under these conditions.

Fire Behavior

Fir forests have a deep, densely packed duff layer. It dries slowly and when it burns, supports a smouldering, slow moving fire front. Natural fires monitored in Yosemite National Park move slowly with an average rate of spread of 1/3 chain per hour, a flame length of 10 inches and scorch height of 5 feet. The maximum red fir spread rate observed in Yosemite is 2 chains per hour (Botti, 1980). More rapid spread occurs on unusually hot, dry or windy days. When relative humidity drops below 20% the method of spread is by spotting into punky logs or snags ahead of the fire front.

Without suppression action natural fires in true fir are of long duration with creeping, low intensity fire spread. Occasional torching of fir regeneration and high intensity burning around heavy fuel accumulations will occur (Kilgore, 1971). The potential exists for stand-destroying fire on steep, south facing slopes with heavy fuels and dense regeneration. Such behavior was observed in Crater Lake National Park in 1978 (Sholley, 1980; Mastrogiuseppe, 1980).

Differences in fire behavior between red and white fir forests are due to the elevation gradient. The snow pack is deeper and the mean temperature is lower in the red fir forest. Fuels dry out sooner in the white fir, and consequently, although fuel loadings are comparable, fire intensity and rate of spread are greater.

Heavy dead fuel loadings contribute substantially to fire behavior when 1000 hour time lag fuel moisture drops under 10%. This occurs only in dry years in the white fir belt and very rarely in the red fir zone.

Succession

Fire frequency determines the percent of fir in a mixed coniferous forest (Agee et al, 1977; Bock & Bock, 1969). Frequent fire eliminates fir seedlings and favors pine habitats. Preliminary fire scar data indicate a natural fire frequency of approximately 60-70 years in the fir cover type (Swanson, 1980). The short growing season and heavy snow pack may be important in limiting fire in the fir habitat.

Fir forest is the climax community above 5000 feet over much of the Forest. A mature fir forest is an indication that an area has not been subject to major disturbance for long periods of time. Yet fire scars are found on old firs throughout the planning area. Light, periodic fire plays a role in the fir community, chiefly to reduce the fuel loads and to thin dense reproduction. Low fire frequency allows the establishment of firs old enough to withstand fires that do occur. Small fires produce openings where lodgepole seedlings become established. Stand destroying fires become brush fields that are replaced by fir in time.

WOODLAND COVER TYPE

Cal. Veg. Series: Maple-Dogwood, Cottonwood-Alder, Quaking Aspen and Cottonwood.

Although woodland habitats make up a small percentage of the Forest, they are proportionally more important to wildlife and recreation. The woodland habitat is riparian, occurring in drainages and at the base of slopes. Cottonwood, aspen or alder form the overstory on these sites.

Stimulation by periodic burning is necessary to aspen regeneration. Aspen rarely reproduces by seed and parent plants will not reproduce vegetatively by suckers unless burned or cut. The best regenerative response occurs from intense fires that destroy parent plants and remove duff and ground cover (Grueull and Loupe, 1974). Like aspen, alder and cottonwood resprout after fire but they are not fire dependent.

Natural fire starts are unlikely in woodland areas. In fact, woodland sites may serve as fire breaks because they are wet.

All woodland sites occur in small areas interspersed in conifer habitat types. Fires originating in surrounding vegetation types will burn through aspen patches with rejuvenating effects. In their present, decadent condition aspen stands are quite flammable. Many trees are dead, diseased or down and a fuel ladder of invading fir is present. An area mapped as aspen near the Lost Creek "Hot Rock" is now completely converted to fir habitat (Denniston, 1980). Wright (1977) estimates that aspen stands in conifer areas cannot survive more than 100-200 years without fire.

BLACK OAK

Cal Veg.: Black Oak

Black oak occurs interspersed with the wedgeleaf ceanothus blue oak and annual grass types in the front country of the Almanor District. It also occurs mixed with the Jeffrey pine type in the Pitt River drainage.

Fire Adaptations

Black Oak

Black oak of all ages are sensitive to fire, regardless of inensity. Crown fire is fatal and even ground fires cause vertical wounds to the trunk and scorching of the cambium (McDonald, 1969). The trees respourt vigorously after fire, producing up to 100 sprouts per stump (McDonald, 1980).

Fuel Loadings

Fuels are best described by hardwood litter models, NFDRS E and R and NFFL Model 9. Leaf litter is approximately 4 tons per acre with one-half of the total matted and decomposing. The remainder is fluffy, burnable leaf cast (Blonski, 1981).

Fire Behavior

Fire may burn intensely as it enters the edge of a black oak grove, but quickly becomes a smouldering slow moving ground fire. Flame heights average a foot but may be very low if the decomposing leaf layer is wet (Blonski, 1981).

Succession

Black oak has increased in distribution with fire exclusion. Frequent fire in front country, Jeffrey pine and mixed conifer-pine habitats limited its occurrence. It was shaded out by the tall canopy found in mature conifer forests. It is favored both when conifers are logged out and by smaller average conifer height.

BLUE OAK TYPE

The Blue oak type occurs intermixed with the wedgeleaf ceanothus, annual grasslands black oak types. A mosaic of the three types covers most of the western slope of the Forest between 500 and 3000 feet. The distribution of the the types coincides with changes in soil composition and topography (Griffin, 1977). The blue oak and annual grassland are found on the shallower Toomes soils. The deeper Stover soil series supports the wedgeleaf ceanothus types, other brush stands and black oak. (Biswell and Gilman, 1961).

An isolated group of digger pines is found up to 5000 feet on the Hat Creek Rim where precipitation is 16 to 18 inches per year (Rantz, 1969), (Critchfield and Griffin, 1972). The Hat Creek stand does not include blue oak.

The major species are blue oak and digger pine. Black oak, live oak, and ponderosa pine occur in moister areas with deeper soils. MacNab cypress is found occasionally on rocky ridges. Non-sprouting chaparral species in the understory are wedgeleaf ceanothus, whiteleaf manzanita and common

manzanita. Poison oak, barberry and deerbrush, all vigorous sprouters, are also part of brush canopy. An understory of annual grasses, mostly cheatgrass and downy chess, is widespread. Perennial grasses occur in drainages and on north slopes.

Adaptations of Species

Blue Oak

Blue oak is a deep rooted, long-lived tree. There has been very little blue oak regeneration in the last 80 years because of acorn consumption by cattle, deer, rodents and birds and heavy seedling predation by pocket gophers and grazing animals (Neal, 1980). At present blue oak is perpetuated by sprouting after burning.

Mature trees are little affected by fire because of their thick, insulative bark and high canopies.

Digger Pine

Digger pine lives where fire burns frequently. Yet it is killed or damaged by fire at all stages of growth. Its adaptive strategies are twofold: 1. Digger pine matures and sets seed rapidly, within the natural fire period for the front country. Seed production is heavy and regular. Seedlings do well on the mineral seedbed produced by fire. 2. It is drought resistant and can grow on the shallowest soils, where natural rock barriers and light ground cover limit fire spread and intensity.

Digger pines are pitchy. On the Finley Burn mature pines were consumed by fire when flashy ground fuels ignited the pitch flowing to the base of the trees (Merrifield, 1981). The fire moved up the pitch into the canopies. Young trees are killed or severely damaged by fire (Lawrence, 1966).

Seeds mature in fall and the cones open slowly, releasing seed over several months. Sudworth (1967) observes that Indians heated cones in fires to hasten opening. It is probable that digger pine are adapted to shed seed

on the mineral seedbed produced by fire. Reproductive success probably depends on the time of year the fire burns and the amount of seed consumed by rodents and birds.

Digger pines rarely live longer than 60 to 80 years because of fire frequency (Sudworth, 1967).

MacNab Cypess

MacNab cypress has a scattered distribution in the blue oak type. It occurs on ridgetops where fuels are light. The foliage and structure appear to be highly flammable.

Fuel Loadings

Fuels are best described by NFDRS Model A or NFFL Model I where cured annuals are the main burnable substance. Where oaks are denser, hardwood litter models (NFDRS E and R, NFFL Model 9) could be used.

Fuel loadings are low in this habitat type, usually under 5 tons per acre.

Fire Behavior

Indicated fire behavior is of low intensity with rapid rates of spread through annual grasses. Rates of spread in cheatgrass are estimated at 23 chains per hour (Maxwell and Ward, 1980). Mature blue oaks are not damaged. Occasional mature pines may burn when the pitch on the bark is ignited. Where an understory of brush or digger pine seedlings has developed, rate of spread decreases and intensities increase. Fuel ladders increase the possibility of torching digger pine.

Fire behavior is heavily influenced by the mosaic of oak savannah, annual grassland brushfields and natural rock barriers found in the Lassen front country. Cover types are broken and rate of spread and intensity change as fire passes from one type to another. Fluctuations in humidity influence fire behavior because flashy fuels are essential to the spread of fire.

Succession

The blue oak cover type is the climax vegetation cover in the hot, dry foothills. Natural fire frequency is estimated from 10 to 20 years. In the past, oak savannah was burned frequently by Indians to clear the ground for acorn harvesting and later by ranchers, to encourage annual grass growth.

Changes in fire frequency affect the spacing and relative percentages of trees, the amount of fuels, the understory composition and fire intensities.

With frequent fire the cover type is an open oak savannah with scattered pines and an annual grass understory. Frequent fire kills seedlings of non-sprouting shrubs before they produce seed. A study by Brooks (1971) showed effects of fire and grazing on blue oak density. Grazed plots had 230 trees per hectare, ungrazed plots had 329 trees per hectare, plots with no known fire record had 336 trees per hectare and plots burned in the last decade averaged 114 trees per hectare.

Digger pines were probably less frequent in the past because of their susceptibility to fire. They occurred on ridges and on the shallowest soils where surface rock outcrops form natural barriers to fire spread and brush and grass cover is sparse. Black oak is also limited by frequent fire, to north facing, moister slopes.

Fire exclusion has allowed the growth of an understory of brush and digger pine. Fire intensities are greater and usually kill mature digger pine that might have survived a light ground fire in flashy fuels. Damage to blue oaks is also more likely under these fuel conditions.

MONTANE CHAPARRAL COVER TYPE

Cal. Veg. Series: Greenleaf Manzanita, Montane Mixed Shrubs, Huckleberry Oak

Montane chaparral describes the brushfields found in a scattered pattern throughout the timber producing portion of the Lassen National Forest. Several Cal. Veg. series are included.

1. The Greenleaf Manzanita Series, the most extensive, is a successional stage which follows fire or timber harvest on productive soils.

2. Montane Mixed Shrubs occur in the red fir belt and above. It may or may not be a successional stage depending on soil depth.

3. The Huckleberry Oak Series is an edaphic climax found on poor, shallow soils.

Major species are greenleaf manzanita, tobacco brush, bittercherry, huckleberry oak, chinquapin, mountain whitethorn, silktassel, deerbrush, serviceberry, bitterbrush, redbud, pinemat manzanita and squaw carpet.

Fire Adaptations of Species

Greenleaf Manzanita

Greenleaf manzanita is a major component of montane chaparral. After burning it sprouts from a well developed burl at the base of the plant. It reseeds abundantly following burns. Snow cover causes layering or rooting from stems pressed against the soil. These strategies insure that greenleaf manzanita is re-established quickly after burning. Greenleaf manzanita has a longer lifespan than either mountain whitethorn or tobacco brush, the other main components of successional brushfields.

Flammability of greenleaf manzanita is influenced by the high dead to live ratio in decadent stands and volatile oils produced by the foilage.

Mountain Whitethorn

Mountain whitethorn stump sprouts freely after burning. Fire scarifies seed and breaks dormancy. Research by the North Kings Deer Herd Management Study showed an increase from an average 66 plants per acre to 4600 plants per acre the year following burning of experimental plots. The survival rate after 4 years was 1800 plants per acre. (Bertram, Ashcraft and Cook, 1979).

Tobacco Brush

Tobacco brush is another fire adapted species found on many old burns. It cannot live under a forest canopy. Tobacco brush is capable of sprouting after fire. It also roots from the stems when it contacts the soil (Biswell, 1974). Burning scarifies the seed and prepares it for germination after over wintering. The seed is common in forest soils and remains viable for several hundred years, the upper limit of fire periodicity in this area (Zavitkovski and Newton, 1968). Tobacco brush, along with the other Ceanothus species, fixes nitrogen and may improve the site for conifer succession. Tobacco brush becomes senescent at 15-20 years and openings develop where conifer seedlings can flourish. (Zavitkovski and Newton, 1968).

Deerbrush

Deerbrush resprouts after burning. Seed germination is greatly enhanced by fire, both because of seed scarification and opening of the canopy. Deerbrush becomes decadent and dies out if fire is excluded for over 50 years. Seed, however, remains alive in the soil for long periods.

Other Species

Bittercherry and chinquapin are sprouting species with a scattered distribution in the montane chaparral cover type.

Pinemat manzanita and squaw carpet are common as ground cover in timber stands. Neither sprout but both root freely from prostrate stems (McMinn, 1939). On montane chaparral areas at middle elevations they are shaded out

by erect species. Pinemat manzanita is the main component of steep, high altitude brushfields in Lassen Volcanic Park.

Fuel Loadings

Much of the successional montane chaparral type can be classified as NFDRS Fuel Model F. Where brush is taller or contains a higher percentage of dead material Model B applies. The NFFL Models is usually 6 with some 4 and 5.

Dead and down fuel loadings range from almost nothing in young stands to 5 tons per acre in patchy greenleaf manzanita with some slash to 37 tons per acre in heavy stands of tobacco brush with many down logs (Maxwell and Ward, 1980). Residue is mostly in the two smallest size classes except when larger fuels result from the remnants of a timber stand.

Fire Behavior

Fire behavior in brushfields is dictated by the live fuel moisture, dead to live fuel ratio, wind speed, relative humidity and slope. When live fuel moistures drop below 100% fire will carry in brush. This does not occur until late summer and in some years not at all. Live fuel moisture data was taken for six years at Manzanita Lake, located at 5800 feet. The average never dropped below 90 and dipped below the warning level of 100 only in August. (California Chaparral Live Fuel Moisture Conditions, 1979). In the drought year of 1979, live fuel moistures not usually observed until late September were observed in August. Extreme fire behavior, rapid rates of spread and flame heights over 10 feet are to be expected if ignition and low live fuel moisture coincide.

When live fuel moistures are high fire burns with low, spotty intensity in the montane chapparal habitat. It consumes the flashy ground fuels in the 0-1 inch size class range and ignites some down logs and snags. Data from the Pacific Northwest Natural Photo Series suggest spread rates of 7 to 13 chains per hour and flame heights of 5-7 feet with no slope, 4 mph effective midflame winds and 4% fuel moisture (Maxwell and Ward, 1980).

Succession

Brush fields are the first successional stage following intense, stand destroying fire or volcanic disturbance in fir, yellow pine or mixed conifer cover types. The size of existing brush fields indicates the extent of such fires or disturbance in the past. They range from 1 to 1700 acres and average 70 acres. The cover type is transient unless succession is interrupted by burning. Some brush species show signs of decadence 25 to 50 years after establishment (Biswell, 1974). Comparison of 1942 and 1973 aerial photos of Lassen National Park give visual evidence of the conversion of brush fields to fir stands (Denniston, 1980). However, re-establishment of fir can be very slow in large brush fields because of the distance to seed sources (Biswell, 1974). Around Eagle Lake brushfields have resulted from stand destroying fires in the transition between conifer and sage/juniper habitat. In these burns, the loss of the conifer overstory has caused microclimatic shifts that limit the growth of young trees in plantations. In the Hat Creek Valley, another low precipitation zone, succession from brushfields to a mixture of pine, curl-leaf mountain mahogany and juniper can be seen.

As brush fields age, two factors influence succession. First, shade tolerant fir seeds germinate under the cover, gaining dominance by shading out brush. As the brush becomes decadent openings develop where more fir and pine seedlings can grow. Continued exclusion of fire will lead to the eventual loss of the montane chaparral type. Second, the fields become more flammable with time because the dead to live fuel ratio increases. If natural fire is allowed to burn in brush fields it will kill fir regeneration, rejuvenate sprouting species and break dormancy of fallen seeds of other species, particularly Ceanothus.

Brushfields on unproductive soils, indicated by the presence of huckleberry oak, constitute an edaphic climax. When burned the oak and other brush will resprout.

Brushfields composed of pinemat manzanita are found in the red fir belt. Succession is slower than at lower elevations. Fields of pinemat manzanita may also be an edaphic climax on shallow soils.

Effects of Fire on Resources

Montane chaparral is important to a number of wildlife species adapted to successional types. Fire is essential to the maintenance of the type and to its continued usefulness to wildlife.

Almost all of the brush species mentioned are important to wildlife as a food source.

The new shoots produced by greenleaf manzanita are heavily utilized by deer the first two years after fire (Sampson and Jesperson, 1963). Mature plants are a significant browse source and the fruit is eaten by deer, bear, rodents and birds.

Mountain whitethorn forms a large part of the diet of deer on the Forest due to high protein content and palatability. Tobacco brush, another Ceanothus species, is fair deer browse. The leaves and twigs of bitter cherry are eaten by deer and many animals eat the berries.

Deer use the brush as cover.

WEDGELEAF CEANOTHUS

Cal. Veg.: Wedgeleaf Ceanthus Series

The wedgeleaf ceanothus type is found below 3000 feet in the front country of the Lassen National Forest. It is characterized by dense, single species brushfields, usually less than 100 acres in size. The wedgeleaf ceanothus type is interspersed with and intergrades with the blue oak and the black oak cover types. A fire dependent vegetation type, it shows evidence after 50 years of suppression efforts, of decadence and decay.

Fire Adaptation of Species

Wedgeleaf Ceanothus

Germination of seeds occurs the winter following scarification by fire. Taproot extension is rapid, averaging over 4 inches in length by April of

the spring when seed germinates. First seed is produced at 5-7 years. The seed remains dormant in the soil until fire scarification. Starting at 15 to 20 years brushfields become increasingly flammable due to dead material, the airy structure of plants and dense stand structure. If brushfields burn, they are completely consumed, providing ideal conditions for seedling growth.

Other Species

Birchleaf mountain mahogany, Brewer oak, scrub oak, scrub live oak, greenleaf manzanita, yerba santa, silktassel and flannel bush are lesser components of the wedgeleaf ceanothus type. All resprout after burning.

Common manzanita, hoary manzanita and whiteleaf manzanita also occur intermixed with wedgeleaf ceanothus. Neither sprout but both reseed vigorously after fire.

Fuel Loadings

The wedgeleaf ceanothus type fits NFDRS Model B and NFFL Model 4.

Typical brushfields are 35 years of age with 16 to 35 tons of vegetation per acre (Camarena, 1980). The dead to live ratio is about 35 percent. Live fuels are continuous and well aerated.

Dead fuel loading is very low. There is almost no litter layer except under the deciduous shrubs, brewer oak and scrub oak.

Fire Behavior

Fire behavior in wedgeleaf ceanothus depends on the age of the brush and the time of year it burns.

Front country wildfires move rapidly up south-facing slopes in the steep, dissected terrain. They creep down north slopes, making some runs to the top. Control is usually achieved on the sparsely vegetated ridgetops.

Early season fires burn rapidly, consuming leaf litter and annual grasses in the blue oak type without igniting mature brushfields. Fire may burn through flashy fuels in ceanothus too young to have achieved crown closure. One example of this kind of fire was the Upper Slab Fire in 1976. Mid to late season fires burn intensely through the brushfields, which are usually less than 100 acres in size, and burn with low to moderate intensity in the light fuels of the adjoining blue oak type.

High intensity fire is the rule in mature or decadent ceanothus fields. Brushfields burn when live fuel moisture drops below 100. Brush was successfully burned, however, on the Finley Butte prescribed fire when live fuel moistures averaged 105. Live fuel moistures this low occur in the front country from mid-July until the first fall rains. In dry years the oaks are drought deciduous and add dead fuels that increase fire potential.

Succession

Healthy wedgeleaf ceanothus is maintained by a natural fire frequency of 15-20 years. Continued fire suppression could restrict its occurrence in the Lassen front country.

Wedgeleaf ceanothus forms dense, even-aged brushfields. Many of them have not burned in 50 years, an age given by Biswell (1974) as the onset of death and decadence. There are no replacements because wedgeleaf ceanothus seeds remain dormant until burned.

There are insufficient fire fuels to support ground fire under dense ceanothus. When enough die off, fuel moisture under 100 and an ignition source combine, the brush will burn completely. Chaparral rarely burns until it contains 20% dead material (Harrell, 1979). Harrel estimates that mixed brush approaches 20% dead to live ratio at 30 years.

Wedgeleaf ceanothus begins seed production early, at 5 to 7 years of age, when the brush neither contains enough dead material nor has sufficient closure to burn. Brushfields remain fire proof, except under extreme conditions, until a number of seed crops are produced and accumulate in the

soil. Fire scarifies the hard seed coats, allowing water absorption and seed germination after the next rainy season. Seedlings are numerous. The best regeneration on the Finley Burn is in areas that burned the hottest (Airola, 1981).

With fire exclusion, wedgeleaf ceanothus grows decadent and dies completely out at approximately 100 years (Biswell, 1974). Longer lived brush species such as manzanitas may become more prevalent where single species stands of ceanothus once stood. Digger pine, capable of germinating under brush cover, may also invade the brushfields. Seed from wedgeleaf ceanothus remains viable in the soil for long periods, and eventually, when wildfire burns again, will revegetate the area.

Effects of Fire on Resources

The Wedgeleaf ceanothus type is extremely important as winter range for the Tehama deer herd. Brush species provide forage. The fire related mosaic of vegetation provides habitat and cover. The regenerative effects of fire are essential to the continued usefulness of the habitat to wildlife.

SAGEBRUSH SHRUB

Cal. Veg: Basin Sagebrush and Low Sagebrush

Sagebrush shrub is widespread on the forest. It is found in large, flat openings in the Jeffrey pine and mixed conifer-fir types.

Fire Adaptations of Species

Low Sage

Low sage is eliminated by fire. The plants burn intensely and do not resprout. Low sage is found on shallow soils with less than 20 inches to bed rock, hardpan or abrupt texture change (S.C.S., 1978).

Big Sage

Big sage grows on deeper soils. It is easily killed by fire and does not resprout. Seed is too heavy to spread far from parent plants and does not remain viable in the soil for more than 3 to 5 years (Wright et al, 1979).

Silver Sage

Silver sage is the only sagebrush capable of resprouting after disturbance. However, it occupies a narrow ecological niche, growing only in ponded clay basins and deep, wet loamy soils (S.C.S., 1978).

Grasses

Grasses have a competitive edge over sage where fire is a factor. Bluebunch wheatgrass and squirrel tail grass are more fire tolerant than other grasses. Threadleaf sedge, Idaho fescue, bluegrasses and needlegrasses are more heavily damaged by fire. The majority survive and recover within several years.

Fuels

The fuels situation is best described by NFRDS model T and NFFL models 5 or 6. There are few dead fuels in the sagebrush shrub type. Typical loadings are less than one-and one-half tons per acre (Maxwell and Ward, 1980).

Fire Behavior

Sagebrush varies in flammability. Low sage flats rarely burn unless wind speeds are 30 miles per hour. When they do burn the consumption is spotty. Grass cover is heavily grazed and fire does not carry well from bush to bush.

Big sage burns somewhat more easily. It also is dependent on flashy fuels and high winds to carry fire.

Succession

Sagebrush shrub is the most modified cover type on the forest. Most of the sagebrush type was once perennial grassland. Factors responsible for conversion are grazing, fire exclusion and invasion by exotic annuals.

Selective grazing has reduced the percent of perennial grasses, sedges, rushes and forbs while leaving the unpalatable sagebrush. When fire does burn the sage, the seed source for perennial grasses is unavailable and the disturbed ground is colonized by agressive annuals. In most cases, however, flashy fuels are now insufficient to carry fire. Sage has replaced perennial grasses both because of fire exclusion and cattle grazing.

HERBACEOUS COVER TYPE

Cal. Veg. Series: Perrenial Grass, Sedge-Rush

There are many small meadows above 6000 feet in depressions, drainages and around lakes. Large meadows occur interspersed with the yellow pine type in broad, flat valleys and in drainages.

There is concern that higher elevation meadows are being lost to lodgepole invasion because of the exclusion of fire. At lower elevations, sage species are invading. Three major factors govern the balance between invading species and meadow: 1) fire, 2) water table fluctuations, and 3) grazing influences.

Charcoal layering indicates that meadows in Yosemite National Park and Sequoia National Park burn once every 250 to 300 years (Botti, 1979; Leonard et al, 1968). Fire is probably more frequent at lower elevations. Normally, fire does little damage to grasses and sedges. Rhizomatous forms benefit and bunchgrasses recover within several years. Lodgepole and sage encroachment is reduced by fire.

Higher water levels kill invading lodgepole and sage. Drops in water table speed lodgepole or sage succession. Meadows were profoundly effected by intensive sheep grazing in the past both in species composition and coverage. Flammability is reduced by cattle grazing on the Forest.

Fires burn at varying depths and intensities in meadows. Fire behavior and impact depend on water level and the degree to which grasses have cured. Damp meadows could serve as natural fire barriers. Yet meadows burn deeply in drought years when complete drying occurs.

SPECIES LIST (Munz and Keck, 1970)

Aspen	Populus tremuloides Michx.
Barberry	Berberis sp.
Bigleaf maple	Acer macrophyllum Pursh.
Birchleaf mountain mahogany	Cercocarpus betuloides Nutt. ext. & G.
Bitterbrush	Purshia tridentata (Pursh.) D.C.
Bittercherry	Prunus emarginata (Dougl.) Walp.
Black cottonwood	Populus trichocarpa T.&G.
Black oak	Quercus Kelloggii Newb.
Blue oak	Quercus Douglasii H.&A.
Bluebunch wheatgrass	Agropyron spicatum (Pursch) Scribn. & Sm.
Bluegrass	Poa sp.
Bottlebrush squirreltail	Sitanion hystrix (Nutt.) J.G. Sm.
Brewer oak	Quercus Garryana var. Breweri (Engelm. in Wats.) Jeps.
Cheatgrass	Bromus tectorum L.
Common manzanita	Arctostaphylos manzanita Parry.
Curlleaf mountain mahogany	Cercocarpus ledifolius Nutt.
Currant	Ribes sp.
Deer brush	Ceanothus integerrimus H&A.
Digger pine	Pinus Sabiniana Dougl.
Dogwood	Cornus Nuttallii And.
Douglas fir	Pseudotsuga Menziesii (Mirb.) Franco
Downy chess	Bromus mollis L.
Dwarf mistletoe	Arceuthobium sp.
Flannelbush	Fremontia californica Torr.
Green rabbitbrush	Chrysothamnus vacidiflorus (Hook.) Nutt.
Greenleaf manzanita	Arctostaphylos patula Greene.
Grey rabbitbrush	Chrysothamnus nauseosus (Pall.) Britton
Hoary manzanita	Arctostaphylos canescens Eastw.
Huckleberry oak	Quercus vaccinifolia Kell.
Idaho fescue	Festuca idahoensis Elmer.
Incense cedar	Libocedrus decurrens Torr.
Jeffrey pine	Pinus Jeffreyi Grev. & Balf. in A. Murr.
Lodgepole pine	Pinus Murrayana Grev. & Balf. in A. Murr.
Low sage	Artemesia arbuscula Nutt.

MacNab cypress	Cupressus Macnabiana A. Murr.
Mountain alder	Alnus tenuifolia Nutt.
Mountain big sagebrush	Artemesia tridentata vaseyana
Mountain hemlock	Tsuga mertensiana (Bong.) Carr.
Mountain misery	Chamaebatia foliosa Benth.
Mountain whitethorn	Ceanothus cordulatus Kell.
Needlegrass	Stipa californica Merr. & Davy.
Needlegrass	Stipa occidentalis Thurb.
Pinemat manzanita	Arctostaphylos nevadensis Gray.
Poison oak	Rhus diversiloba T.&G.
Ponderosa pine	Pinus ponderosa Dougl. ex. P&C. Lawson
Red fir	Abies magnifica A. Murr.
Redbud	Cercis occidentalis Torr. ex Gray
Rush	Juncus sp.
Scrub live oak	Quercus Wislizenii frutescens Engelm.
Scrub oak	Quercus dumosa Nutt.
Sedge	Carex sp.
Serviceberry	Amelanchier sp.
Sierra chinquapin	Castanopsis sempervirens (Kell.) Dudl.
Silktassel	Garrya Fremontii Torr.
Silver sage	Artemesia cana bolanderi
Squaw carpet	Ceanothus prostratus Benth.
Sugar pine	Pinus Lambertiana Dougl.
Threadleaf sedge	Carex filifolia Nutt.
Tobacco brush	Ceanothus velutinus Dougl. ex Hook.
Wedgeleaf ceanothus	Ceanothus cuneatus (Hook.) Nutt.
Western juniper	Juniperus occidentalis Hook.
Western white pine	Pinus monticola Dougl.
White fir	Abies concolor (Gord. and Glend.) Lindl.
Whitebark pine	Pinus albicaulis Engelm.
Whiteleaf manzanita	Arctostaphylos viscida Parry
Yerba santa	Eriodictyon californicum (H.&A.)

CITATIONS

Agee, J.K., R. Wakimoto and H.H. Biswell. 1977. Fire and fuel dynamics of Sierra Nevada conifers. Forest Ecology and Management, 1: 255-265.

Airola, D. 1981. Wildlife Biologist. Almanor RD, Lassen NF. Personal communication.

Alexander, M.E. and F.G. Hawksworth. 1975. Wildland fires and dwarf mistletoe: A literature review of ecology and prescribed burning. USDA Technical Report RM-14. 12 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Bertram, R.C., G. Ashcraft and W. Cook. 1979. Prescribed burning to regenerate mountain whitethorn, Ceanothus cordulatus for deer browse. Ca. Dept. of Fish and Game and Sierra NF.

Biswell, H.H. and J.H. Gilman. 1961. Brush management in relation to fire and other environmental factors on the Tehama deer winter range. California Fish and Game 477: 357-374.

Biswell, H.H. 1974. Effects of fire on chaparral, In Fire and ecosystems. T.T. Kozlowski & C.E. Algren, eds., p. 321-365. Academic Press, New York.

Blonski, K. 1981. Fuels specialist, Almanor RD, Lassen NF, USDA. Personal communication.

Blonski, K. and J. Schramel. 1981. Photo series for quantifying natural forest residues in the Southern Cascade and Northern Sierra Nevada Ranges. Pacific Southwest Range and Experiment Station. 77 pages. in press.

Bock, J.and C. Bock. 1969. Natural reforestation in the northern Sierra Nevada-Donner Ridge Burn. Tall Timber Ecological Conference, 9: 119-126.

Botti, S. 1979. Natural, conditional and prescribed fire management plan for Yosemite National Park. On file at Almanor Ranger District.

Botti, S. 1980. Plant Ecologist, Yosemite National Park, USDI. Letter dated November 25, 1980. On file at Almanor RD.

Brooks, W.H. 1971. A quantitative ecological study of the vegetation in selected stands of the grass-oak woodland in Sequoia Ntl. Park, Ca. Progress report to superintendent, Sequoia Kings Canyon NP, Three Rivers, Ca.

Brown, J.K. 1973. Fire cycles and community dynamics in lodgepole pine forests. In Management of lodgepole pine ecosystems. p. 429-456. D.M. Baumgartner, ed. Wash. State Univ. Coop. Ed. Serv., Pullman.

California Chaparral Live Fuel Moisture Conditions, 1979. USFS, Region 5.

Camarena, A. 1980. EA, Finley Butte Prescribed Burn. Almanor RD, Lassen NF, USDA.

Critchfield, W.B. and J.R. Griffin. 1972. Distribution of forest trees in California. Pac. SW For. and Range Exp. Sta., Berkeley, Ca.

Deeming, J.E., R.E. Burgan and J.D. Cohen. 1977. The national fire danger rating system - 1978. USDA For. Serv. Gen. Tech. Rep. INT-39, 63p. Intermountain Forest and Range Exp. Stn., Ogden, Utah.

Davis, K.B. Clayton and W. Fischer. 1980. Fire ecology of Lolo National Forest habitat types. USDA. Forest Service General Technical Report INT-79. 77 p. Intermountain Range and Exp. Stn.

Denniston, A. 1980. Natural Resources Manager, Lassen Volcanic NP, USDI. Personal communication 11-80.

Griffin, J.R. 1977. Oak woodland. In terrestrial vegetation of California. M.G. Barbour and J. Major, eds. p. 483-515. John Wiley and Sons.

Gruell, G.E. and L.L. Loope. 1974. Relationships among aspen, fire and ungulate browsing in Jackson Hole, Wyoming.

Hall, F.C. 1977. Natural underburning in the Blue Mountains of Oregon. 10 p. Pacific Northwest Range and Exp. Stn.

Harrell, D. 1979. California Chaparral Live Fuel Moisture Conditions. USFS, Region 5.

Johnson, A.H. and G.A. Smathers. 1976. Fire history and ecology, Lava Beds National Monument. Proc. Annual Tall Timbers Fire Ecology Conf. No. 15: 102-115.

Johnson, R.C. 1980. Fire Management Officer, Almanor RD, Lassen NF, USDA. Personal communication 11-80.

Kershaw, K.A. 1973. Quantitative and dynamic plant ecology, 2nd ed., American Elsevier Publ., New York, 308 p.

Kilgore, B,M. 1971. Role of fire in managing red fir forests. In North American Wildlife Conference, 36: pg. 405-416.

Kilgore, B.M. 1973. The ecological role of fire in Sierran conifer forests. Journal Quat. Res., 3, p. 496-513.

Lawrence, G.E. 1966. Ecology of vertebrate animals in relation to chaparral in Sierra Nevada foothills. Eco. 47: 278-291.

Leonard, R., C.M. Johnson, P. Zinke and A. Schultz. 1968. Ecological study of meadows in lower Rock Creek, Sequoia National Park. Progr. rept. in Sequoia NP files, Three Rivers, Calif. 67 p.

Mastrogiuseppe, R. 1980. Resources Management Specialist, Redwood NP, USDI. Personal communication.

Maxwell, W.G. and F.R. Ward. 1976. Photo series for quantifying forest residues. USDA Forest Service Gen. Tech. Rep. PNW-51. 73 p. Pac. NW For. and Range Exp. Stn., Portland, Oreg.

Maxwell, W.G. and F.R. Ward. 1979. Photo series for quantifying forest residues in the Sierra mixed conifer type and Sierra true fir type. USDA Forest Service, Gen. Tech. Rep. PNW-95. 79 p. Pac. NW For. and Range Exp. Stn., Portland, Oreg.

Maxwell, W.G. and F.R. Ward. 1980. Photo series for quantifying natural forest residues in common vegetation types of the Pacific Northwest. USDA FS, Gen. Tech. Rep. PNW-105. 230 p. Pac. NW For. and Range Exp. Stn., Portland, Oreg.

Munz, P.A. and D.A. Keck. 1970. A California flora. University of California Press, Berkeley, 1681 p.

McDonald, P.M. 1969. Silvical characteristics of California black oak. USDA FS Research Paper PSW-53. 20 p. Pac. SW For. and Range Exp. Stn.

McDonald, P.M. 1980. Black oak in forest cover types. F.H. Eyre, ed., p. 122. Society of American Foresters.

McMinn, H.E. 1939, Sixth Edition. An illustrated manual of California shrubs. 663 p. University of California Press, Berkeley.

Merrifield, D. 1981. AFMO, Almanor RD, Lassen NF. Personal communication.

Neal, D. 1980. Blue oak-digger pine. In Forest cover types. F.H. Eyre, ed., p. 126-127. Society of American Foresters.

Olson, C.M. 1978. Foliar moisture content and prescribed burning in Lava Beds Ntl. Mnmt. M.A. thesis. Univ. of Washington, Seattle. 34 p.

Olson, R. 1981. Fuels specialist, Eagle Lake RD, Lassen NF. Personal communication.

Pfister, R.D. and R. Daubenmire. 1973. Ecology of lodgepole pine (Pinus contorta Dougl). In Management of lodgepole pine ecosystems. p. 27-47. D.M. Baumgartner, ed. Wash State Univ. Coop. Ext. Serv., Pullman.

Rantz, S.E. 1969. Mean annual precipitation of the California region. USGS, Menlo Park, California.

Regional Ecology Group. 1981. Cal. Veg., A classification of Californian vegetation. USFS, Region 5.

Sampson, A.W. and B.S. Jespersen. 1963. California range brushlands and browse plants. California Agricultural Exp. Stn. Ext. Service. Man. 33. 162 p.

Sholley, D. 1980. Chief of Visitor Protection and Resources Management. Crater Lake NP, USDI. Personal communication.

Soil Conservation Service. 1978. California range site descriptions. USDA. Unpublished.

Sudworth, G.B. 1967. Forest trees of the Pacific slope. Dover Pub. Inc., New York, 455 p.

Swanson, J. 1980. Forester, Almanor RD, Lassen NF, USDA. Lassen natural fire management planning fire history. Report on file at Almanor Ranger District.

Van Wagtendonk, J.W. 1972. Fire and fuel relationships in mixed conifer ecosystems of Yosemite National Park. Phd. Thesis, Univ. of California, Berkeley. 163.p.

Ward, F.R. and D.V. Sandberg. 1980. Fire behavior tables for NFPS. unpublished.

Wright, H.A. 1977. Unpublished lecture notes on file at Almanor Ranger District.

Wright, H.A. 1978. The effect of fire on vegetation in ponderosa pine forests, a state of the art review. Texas Tech. Univ. University Range and Wildlife Info. Series Num. 2 Pub. #T-9-199. 21 p.

Wright, H.A., L.F. Neuenschwander and C.M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities. A state-of-the-art review. USDA For. Serv. Gen. Tech. Rep. INT-78, 48 p. Intermountain For. and Range Exp. Stn., Ogden, Utah.

Zavitkowski, J. and M. Newton. 1968. Ecological importance of snowbrush (Ceanothus velutinus) in the Oregon Cascades, Ecology 49: 1134-1145.